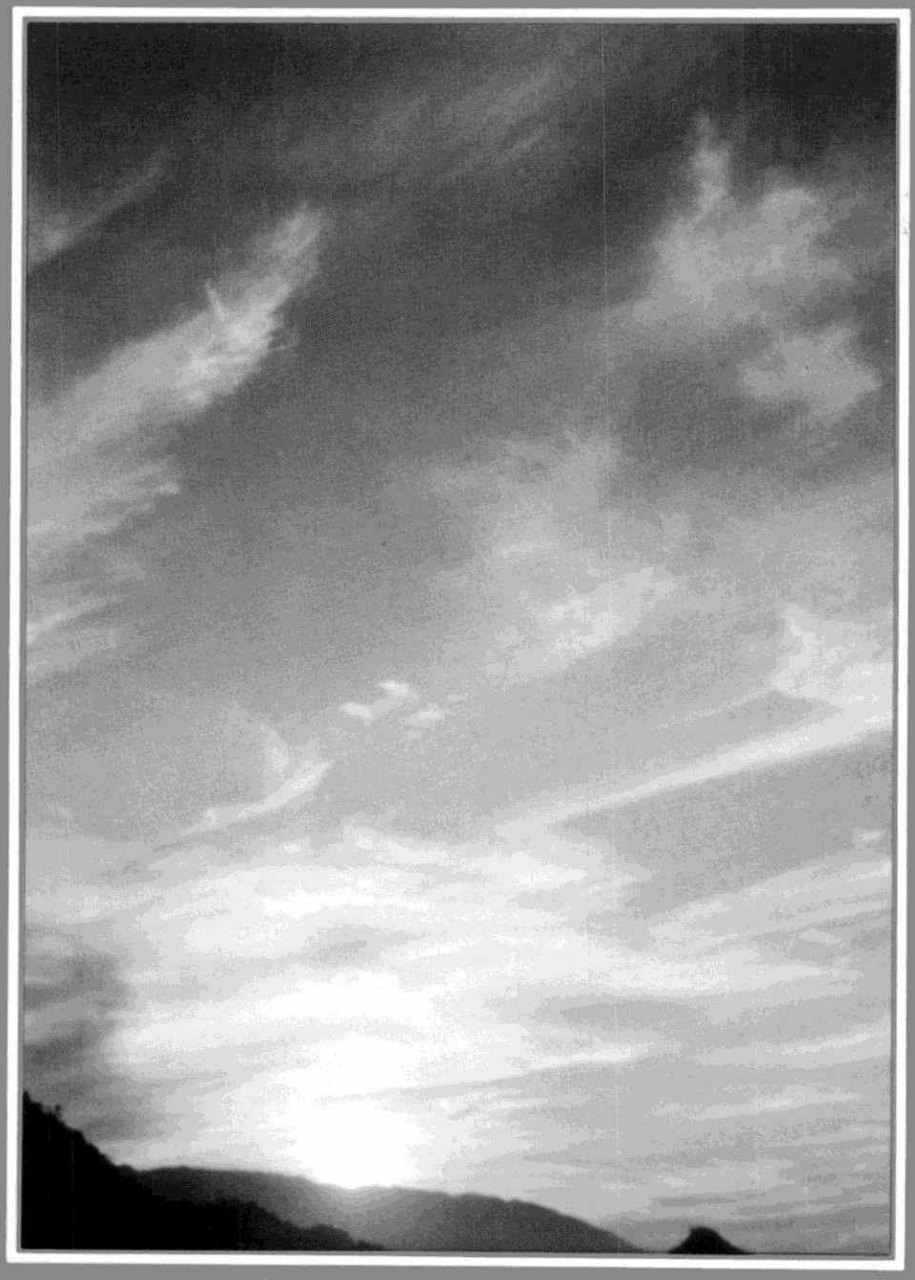

Air Quality in Ontario 1987

Environment Ontario

Jim Bradley
Minister

6190

AIR QUALITY IN ONTARIO
1987

A review of the air quality monitoring program

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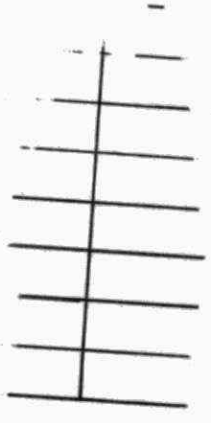
EXECUTIVE SUMMARY

In 1987, the routine air monitoring program in Ontario included the measurement of nine gases at up to 72 locations and the measurement of particulates at 136 locations.

For gases, the provincial criterion most frequently exceeded was that for ozone as the result of medium- and long-range transport from the United States. Of 38 ozone-monitoring stations, 35 exceeded the criterion at least once during the year. Sulphur dioxide and total reduced sulphur criteria were exceeded at some stations as well. The 10-year trends indicate improvement for sulphur dioxide and carbon monoxide, but little change in hydrocarbons, ozone and nitrogen oxides.

For particulates, the 24-hour criterion for total suspended particulate was frequently exceeded: 111 of 136 stations recorded at least one reading higher than the criterion during the year. The one-year criterion was exceeded at 34 stations. Lead measurements at four stations exceeded the criterion, but no other particulate criteria were exceeded. The 10-year trends show improvement in total suspended particulate as well as in each of the commonly monitored metals: copper, iron and lead.

The Air Pollution Index (API), which is the basis of the alert system for air pollution control in Ontario, was higher than the advisory level of 32 at Hamilton only. There were two such occurrences in 1987 with a maximum API of 38 on October 17.



INTRODUCTION

This report describes the 1987 Ontario air quality monitoring program including a summary of the measurements of gases and particulate matter during the year. It is intended for use in conjunction with an appendix which appears in a separate volume.

In order to ensure that the ambient air quality data are of the highest quality, the Air Resources Branch maintains a reference standards laboratory, where quality control and quality assurance programs adhere to both the U.S. National Bureau of Standards and Environment Canada's Pollution Measurement Division standards. Quarterly performance audits of the monitoring equipment and the data acquisition system in the Ministry of the Environment (MOE) network are also carried out.

In this report, the following are discussed for each pollutant: characteristics, effects, Ontario criteria (if any), sources, method of monitoring, locations (and frequency) of sampling, summary of sampling results, and 10-year trend.

Also, tables provide the location of stations and supply sample distribution information which includes means, maxima and the number of exceedances of the Ontario criteria.

The entire continuous (hourly) network is summarized in Appendix Table A-1 and Maps 1 and 2. This table gives station name, numerical identifier, and an indication of the "continuous" pollutants measured. Letter codes indicate whether data are telemetered or chart-read.

The "continuous" pollutants include SP (suspended particles) as well as the following gases:

SO_2 (sulphur dioxide)
CO (carbon monoxide)
O_3 (ozone)
NO_2 (nitrogen dioxide)
NO (nitric oxide)
NO_x (total nitrogen oxides)
THC (total hydrocarbons)
RHC (reactive hydrocarbons)
TRS (total reduced sulphur)

Section A of this report describes each of the "continuous" pollutants in sequence. Section B deals with the Air Pollution Index over the past 10 years.

The particulate (daily) network is summarized in Appendix Table A-3 and Maps 3 and 4. This table provides the station name, numerical identifier and various "daily" pollutants measured. Also, numerals indicate the monitoring cycle frequency in days. Some additional codes are defined in the key at the top of the table. The main particulate pollutants measured are:

TSP (total suspended particulate)
Cd (cadmium)
Co (cobalt)
Cr (chromium)
Cu (copper)
Fe (iron)
Mn (manganese)
Ni (nickel)
Pb (lead)
V (vanadium)
NO_3^- (nitrate)
SO_4^{2-} (sulphate)

Section C describes each of the "daily" or particulate pollutants under the headings of TSP, Lead, Trace Metals, Nitrate and Sulphate.

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GLOSSARY

COH – a measure of the amount of light scattering by particulate matter

criterion – a recommended maximum ambient air exposure (based on effects)

detection limit – the minimum air concentration of a pollutant that can be determined by an analytical method

exceedance – an occurrence which exceeds the Ontario standard

geometric means – calculated by taking the nth root of the product of all (n) values in a data set
– provides a better indication than arithmetic mean of central tendency for a small data set with extreme values

percentile value – the percentage of the data set that lies below the stated value
– for example, if the 70 percentile value is 0.10 ppm, then 70% of the data are below 0.10 ppm

primary pollutant – a pollutant which is directly emitted to the atmosphere

secondary pollutant – a pollutant which is formed from other pollutants present in the atmosphere

"continuous pollutants" – a pollutant for which a continuous record exists; usually pollutants which have hourly average readings (maximum 8760 values per year)

"daily" pollutant – a pollutant for which there exists only a 24-hour or daily value (maximum 365 values per year)

ABBREVIATIONS

AQC – air quality criterion

COH – coefficient of haze

ppb – parts (of pollutant) per billion (parts of air)

ppm – parts (of pollutant) per million (parts of air)

$\mu g/m^3$ – micrograms (of pollutant) per cubic metre (of air)

SECTION A POLLUTANTS MEASURED BY CONTINUOUS MONITORING (HOURLY DATA)

SO_2 SULPHUR DIOXIDE

1.1 Characteristics

- Colorless gas
- Strong, pungent odor over 0.5 ppm

1.2 Effects

One-hour average

less than 0.16 ppm – no known effects
0.16 ppm – injurious to sensitive species of vegetation in combination with ozone
0.34 ppm – odorless, increasing vegetation damage
2.00 ppm – increasing sensitivity of asthmatics and bronchitics

1.3 Ontario Criteria

0.25 ppm (one hour)
0.10 ppm (24 hours)
0.02 ppm (one year)

1.4 Sources

80% of the SO_2 emitted in Ontario originates from non-ferrous smelters and electric utilities. The rest comes from industrial sources including iron ore smelters, petroleum refineries, pulp and paper mills and area sources including vehicles and residential, commercial and industrial heating.

1.5 Method of Monitoring

- Fluorescent excitation of SO_2 by ultraviolet radiation

1.6 Locations of Monitoring

The Appendix provides a description of the provincial SO_2 network (Table A-1).

SO_2 monitoring was carried out at 72 locations in 1987.

1.7 Monitoring Results

The distribution by percentile of the hourly data; the mean; and the maximum one-hour and 24-hour values are provided in the Appendix (Table A-5). Also given are the number of exceedances of the sulphur dioxide criteria (see Section 1.3).

The lowest average levels measured in the province were at Thunder Bay Hospital.

The greatest number of exceedances of the one-hour criterion occurred at Balmertown (sewage treatment plant) and the highest annual mean was measured at Skead.

There were a total of 18 stations which exceeded the hourly criterion at least once and five which exceeded the 24-hour criterion. No station's readings exceeded the annual criterion. (See also Table 1).

1.8 Ten-Year Trend

The trend in mean annual SO_2 at locations which possess a 10-year record is shown in Table A-6 and is summarized for the province in Table 2.

Ambient SO_2 levels improved by about 60% over the 10-year period. This is primarily due to tighter industrial emission controls.

SP SUSPENDED PARTICLES

2.1 Characteristics

- A relative measure of suspended particulate matter of size most likely to reach the lungs (diameter less than the 5-10 micron range)
- Determined by the amount of soiling caused by air flow on a filter medium

2.2 Effects

One-hour average

less than 2.0 COH units – no known effects
2.0 COH units – decrease in visibility
4.0 COH units – soiling evident
6.0 COH units – increasing sensitivity of asthmatics and bronchitics

2.3 Ontario Criteria

1.0 COH unit (24 hours)
0.5 COH unit (one year)

2.4 Sources

- Industrial processes which include combustion, incineration, construction, mining, metal smelting, processing and grinding
- Automobiles
- Natural sources which include windblown soil, forest fires, ocean spray, volcanic activity

2.5 Method of Monitoring

- Continuous paper tape sampler with sampling inlet and flow rate regulated to favour small particles

SP is determined by drawing a known volume of air through a portion of tape and then measuring the reduction in the light transmitted relative to a clean section of tape.

2.6 Locations of Monitoring

The Appendix provides a description of the provincial SP network (Table A-1).

Suspended particles were measured at 39 locations in 1987.

2.7 Monitoring Results

The distribution by percentile of the hourly data; the mean; the maximum one-hour and 24-hour values; and the number of exceedances of the SP criteria (see Section 2.3) are provided in the Appendix (Table A-7).

The lowest levels measured in the province were at Cornwall (Memorial Park) and Thunder Bay where the SP averaged 0.04 units.

The greatest number of exceedances of the 24-hour criterion occurred at the Mission (381 Yonge Street) in Toronto and the highest measured value was at Windsor (2885 Howard Avenue).

There were a total of 27 stations which exceeded the 24-hour criterion at least once and four which exceeded the one-year criterion (see also Table 1).

2.8 Ten-Year Trend

The trend in mean annual SP at selected Ontario cities is shown in Table A-8 and is summarized for the province in Table 2.

Fine particulate, as determined by SP, has remained relatively constant over the past 10 years.

TRS

TOTAL REDUCED SULPHUR

3.1 Characteristics

- Primarily hydrogen sulphide (rotten egg odor)
- Methyl mercaptans (rotten cabbage odor over 5 ppb)

3.2 Effects

One-hour average

less than 5 ppb	– no known effects
5 ppb	– odor threshold
27 ppb	– extremely odorous
1,000 ppb	– sensitive individuals may suffer nausea and headache due to severe odor

3.3 Ontario Criteria

Methyl mercaptans – 10 ppb (one hour)
Hydrogen Sulphide – 20 ppb (one hour)
TRS (from Kraft Pulp Mills) – 27 ppb (one hour)

3.4 Sources

- Industrial – steel industry, pulp and paper mills, refineries
- Natural – swamps, bogs, marshes

3.5 Method of Monitoring

Reduced sulphur compounds are oxidized to SO_2 followed by fluorescent excitation by ultraviolet radiation.

3.6 Locations of Monitoring

The Appendix provides a description of the provincial TRS network (Table A-1).

TRS monitoring was carried out at 29 locations in 1987.

3.7 Monitoring Results

The distribution by percentile of the hourly data; the mean; and the one-hour and 24-hour maxima are provided in the Appendix (Table A-9).

The lowest average levels measured in the province were at two rural stations in the city of Nanticoke. The highest annual mean (6.1 ppb) and the greatest value measured (296 ppb) occurred at Cornwall (St. Peter's School). (See also Table 1.)

3.8 Ten-Year Trend

Table A-10 shows the trend in mean annual TRS for selected Ontario cities while Table 2 shows the provincial trend, with a minimum in 1985, but an increase in recent years.

CO

CARBON MONOXIDE

4.1 Characteristics

Colorless, odorless.

4.2 Effects

One-hour average

less than 30 ppm	– no known effects
30 ppm	– increased cardiovascular symptoms in smokers with heart disease
50 ppm	– increasing cardiovascular symptoms in non-smokers with heart disease. Some visual impairment.

4.3 Ontario Criteria

30 ppm (one hour)
13 ppm (eight hours)

4.4 Sources

Primary source (about 80%) is motor vehicles. A secondary source is fossil fuel combustion for building, heating and commercial/industrial operations.

4.5 Method of Monitoring

- Non-dispersive infrared photometry based on the preferential absorption of infrared radiation by CO

4.6 Locations of Monitoring

The Appendix provides a description of the provincial CO network (Table A-1).

CO was monitored at 24 stations in 1987.

4.7 Monitoring Results

The distribution by percentile of the hourly data; the mean; and the maximum one-hour and eight-hour values are given in the Appendix (Table A-11).

The lowest levels measured in the province were at Ash Street in Sudbury and the highest mean was at the Mission (381 Yonge Street) in Toronto. The highest measured one-hour and eight-hour values were also at the Mission.

There were no exceedances of the Ontario one-hour criterion of 30 ppm. However, the Mission monitor registered six exceedances of the eight-hour criterion. (See also Table 1.)

4.8 Ten-Year Trend

There has been a 50% decline in ambient CO levels (see Tables 2 and A-12). This is due primarily to tighter controls on automotive emissions.

THC/RHC

HYDROCARBONS

5.1 Characteristics

Primarily methane (colorless, odorless) which is present at about 1.5 ppm in the ambient atmosphere. Non-methane hydrocarbons (or reactive hydrocarbons) are usually present at much lower levels. This fraction reacts with nitrogen oxides in the presence of sunlight to form ozone.

5.2 Effects

There are no known direct effects on health or vegetation at ambient levels.

5.3 Ontario Criteria

None

5.4 Sources

Natural sources include trees and other vegetation and decay of animal and plant material.

Anthropogenic sources include motor vehicles, gasoline storage tanks, petroleum and chemical industries, landfill sites, paint manufacturers and fermentation.

5.5 Method of Monitoring

- Calibrated flame ionization detector

5.6 Locations of Monitoring

The Appendix provides a description of the provincial THC/RHC network (Table A-1).

RHC was monitored at seven stations while THC was monitored at 10 locations in 1987.

5.7 Monitoring Results

The distribution by percentile of the hourly data; the mean; and the maximum one-hour and 24-hour values are given in the Appendix (Tables A-13 and A-15).

The locations and values for the lowest, and highest means are given in Table 1. Windsor (University Avenue) measured the highest one-hour maximum concentration of reactive hydrocarbon during the year. The highest total hydrocarbon value for the year was measured at London (Western Fair Grounds).

5.8 Ten-Year Trend

The trend in THC at the seven stations which have a 10-year record is shown in Table A-14 and is summarized for the province in Table 2. Apart from a temporary dip in 1979 and 1980, THC levels have been relatively constant.

NO_2
NITROGEN DIOXIDE

6.1 Characteristics
- Brown gas
- Pungent, irritating odor over .10 ppm
- Oxidation product of nitric oxide (NO) which is the primary NO_x emission
- Reacts with hydrocarbons in sunlight to form ozone, and with water to form nitric acid, a component of acid rain

6.2 Effects
One-hour average

less than 0.10 ppm	– no known effects
0.10 ppm	– odor threshold
0.25 ppm	– some increase in bronchial reactivity in asthmatics
0.52 ppm	– increasing sensitivity of asthmatics and bronchitics

6.3 Ontario Criteria
0.20 ppm (one hour)
0.10 ppm (24 hours)

6.4 Sources
Anthropogenic – high temperature combustion processes including automobiles, power plants, incinerators and several chemical processes. In Ontario, transportation accounts for about 60% of total No_x emissions.

Natural – lightning, soil bacteria.

6.5 Method of Monitoring
Based on the principle of chemiluminescence involving a gas phase reaction of NO with ozone. For NO_2, the sample stream is passed through a catalytic converter where NO_2 is reduced to NO.

6.6 Locations of Monitoring
The Appendix provided a description of the provincial NO_2 network (Table A-1).

NO_2 monitoring was carried out at 30 locations in 1987.

6.7 Monitoring Results
The distribution by percentile of the hourly data; the mean; and the maximum one-hour and 24-hour values are provided in the Appendix (Tables A-16). Also given are the number of exceedances of the nitrogen dioxide criteria (see Section 6.3).

The lowest levels measured in the province were at rural stations in Dorset and the city of Nanticoke where the arithmetic mean was 2 ppb.

The highest annual mean was measured at the Mission (381 Yonge St.) in Toronto.

No stations exceeded either the one-hour or 24-hour criteria. (See also Table 1.)

6.8 Ten-Year Trend
The 10-year trend in NO_2 at selected Ontario cities as shown in Table A-17 and Table 2 is relatively constant.

NO
NITRIC OXIDE

7.1 Characteristics
- Colorless gas
- Oxidizes to NO_2 in the presence of hydrocarbons and sunlight

7.2 Effects
There are no known direct effects on health or vegetation at ambient levels.

7.3 Ontario Criteria
None

7.4 Sources
- Same as for NO_2

7.5 Method of Monitoring
- Same as for NO_2

7.6 Locations of Monitoring
- Same as for NO_2

7.7 Monitoring Results
Dorset had the lowest mean, while the Mission in Toronto had the highest. (See Appendix Table A-18 for the data summaries.)

7.8 Ten-Year Trend
Tables 2 and A-19 show little change in NO over the past 10 years.

NO_x
TOTAL NITROGEN OXIDES

8.
NO_x is assumed to be the sum of NO_2 and NO concentrations in the atmosphere (in parts per million). Normally, this assumption is valid. (See Appendix Table A-20 for the data summaries.)

O_3
OZONE

9.1 Characteristics
- Colorless gas

Major component of photochemical oxidant compounds formed as the result of chemical reactions between nitrogen oxides and reactive hydrocarbons in the presence of sunlight.

9.2 Effects
One-hour average

less than 50 ppb	– no known effects
80 ppb	– injurious to many species of vegetation
120 ppb	– decreasing performance by athletes exercising heavily
200 ppb	– decrease in lung function in exercising subjects, eye irritation

9.3 Ontario Criteria
80 ppb (one hour)

9.4 Sources
Ozone is produced by photochemical reactions and is not directly emitted into the atmosphere in significant amounts. Since it is formed downwind of nitrogen oxide and hydrocarbon sources and capable of travelling long distances through the atmosphere, ozone is a major manifestation of the long range transport of air pollution. Its formation and transport are dependent on meteorological factors. Low level (tropospheric) ozone should not be confused with upper level (stratospheric) ozone which

gives rise to the naturally occurring "ozone layer". The two layers rarely mix.

9.5 Method of Monitoring

An air sample reacts with ethylene to emit visible light (chemiluminescence) of an intensity directly proportional to the ozone concentration. A number of stations still employ fluorescence for ozone detection.

9.6 Locations of Monitoring

The Appendix provides a description of the provincial O_3 network (Table A-1).

Ozone monitoring was carried out at 38 locations in 1987.

9.7 Monitoring Results

The distribution by percentile of the hourly data; the mean; and the maximum one-hour and 24-hour values are provided in the Appendix (Table A-21). Also given are the number of exceedances of the ozone criterion (see Section 9.3).

The lowest levels measured in the province were at the Science Centre in North York where the arithmetic mean was 8.9 ppb.

The greatest number of exceedances of the one-hour criterion occurred at the CN Tower in Toronto where the height of the monitor is 444 metres. The highest mean concentration for the year was recorded at Tiverton.

There were a total of 35 stations which exceeded the criterion at least once. The highest measured concentration was 170 ppb at Sarnia. (See Table 1.)

9.8 Ten-Year Trend

Table A-22 provides the 10-year trend for O_3 at the stations where a 10-year record exists. Table 2 summarizes the data for the province. Despite some variability at specific sites, the provincial mean has remained relatively constant.

TABLE 1 – HIGHLIGHTS OF CONTINUOUS MONITORING 1987

	SO_2	SP	TRS	CO	THC	NO_2	NO	O_3
LOWEST MEAN								
Location	Thunder Bay Hosp. (63022) Thunder Bay MTC. (63200)	Cornwall (56051) Thunder Bay (63200)	Nanticoke (22904) (22907)	Sudbury (77016)	North York (34002)	Nanticoke (22086) Dorset (49010)	Dorset (49010)	North York (34002)
Concentration	0 ppb	.04 units	0.2 ppb	0.1 ppm	1.72 ppb	2 ppb	0 ppb	8.9 ppb
HIGHEST MEAN								
Location	Skead (77012)	Toronto (31049)	Cornwall (56071)	Toronto (31049)	London (15001)	Toronto (31049)	Toronto (31049)	Tiverton (18007)
Concentration	10 ppb	.78 units	6.1 ppb	3.3 ppm	2.99 ppm	36 ppb	88 ppb	33.0 ppb
MOST CRITERION EXCEEDANCES – 1 HR								
Location	Balmertown (61014)	N/A	Cornwall (56071)	–	N/A	–	N/A	Toronto (31190)
Number	87	N/A	556	0	N/A	0	N/A	170
MOST CRITERION EXCEEDANCES – 24 HRS								
Location	Balmertown (61014)	Toronto (31049)	N/A	N/A	N/A	–	N/A	N/A
Number	7	46	N/A	N/A	N/A	0	N/A	N/A
NUMBER OF STATIONS EXCEEDING 1 HR AQC								
Number	18	N/A	19	0	N/A	0	N/A	35
NUMBER OF STATIONS EXCEEDING 24 HRS AQC								
Number	5	27	N/A	N/A	N/A	0	N/A	N/A
HIGHEST MEASURED VALUE – 1 HR								
Location	Wawa (71069)	Windsor (12038)	Cornwall (56071)	Toronto (31049)	London (15001)	S.S. Marie (71068)	Kitchener (26029)	Sarnia (14064)
Concentration	1180 ppb	4.7 units	296 ppb	25 ppm	14.7 ppm	190 pbb	1060 ppb	170 ppb
TOTAL NUMBER OF STATIONS								
Number	72	39	29	24	10	30	30	38

TABLE 2 – TEN-YEAR TREND FOR "CONTINUOUS" POLLUTANTS

POLLUTANT (UNITS)	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	TOTAL NUMBER OF STATIONS
SO_2 (ppb)	10	9	8	7	7	5	6	6	5	4	18
SP (COH unit)	0.36	0.38	0.32	0.33	0.36	0.33	0.37	0.32	0.32	0.32	11
TRS (ppb)	2.3	2.8	2.5	2.3	2.1	2.0	1.5	1.0	1.6	1.9	4
CO (ppm)	1.2	1.1	0.9	1.0	0.9	0.7	0.7	0.7	0.6	0.7	13
THC (ppm)	2.18	1.87	1.87	2.03	2.09	2.12	2.23	2.24	2.14	2.14	7
NO_2 (ppb)	26	22	21	20	20	19	20	19	20	20	15
NO (ppb)	23	22	17	22	17	17	20	18	19	21	15
O_3 (ppb)	23	20	20	19	20	20	20	21	19	20	18

SECTION B
THE ONTARIO AIR POLLUTION INDEX (API)

10.1 Characteristics

The API is the basis of an alert and control system to warn of deteriorating air quality and is derived from 24-hour running averages of sulphur dioxide and suspended particles. Research studies have linked respiratory illness to high concentrations of sulphur dioxide and particulates.

10.2 Legislation

The Ontario Environmental Protection Act (1971) authorizes the Minister of the Environment to order any source not essential to public health or safety to curtail or cease its operations when air pollution levels which may be injurious to health occur.

10.3 Operation of the System

The API is computed each hour based on the past 24 hourly values for SO_2 and SP. If the index reaches a value of 32 (as for example when SO_2 = 0.1 ppm and SP = 1.0) and if the Duty Meteorologist predicts a continuation of adverse atmospheric conditions for at least six hours, an Air Pollution Advisory is issued. Owners of significant sources of pollution are advised to prepare for possible curtailment of operations.

If the index reaches 50, and if at least six hours of adverse atmospheric conditions are forecasted, owners of major sources will be ordered to curtail operations. This is the First Alert Level.

A Second Alert is issued at an API of 75, and further curtailment may be ordered.

The Air Pollution Episode Threshold Level occurs at an API of 100. If atmospheric conditions are not expected to improve for at least six hours, owners of all sources not essential to public health or safety will be ordered to cease operations.

10.4 Air Pollution Index Levels (1978-1987)

A history of the Air Pollution Index levels over the last 10 years of its operation is provided in Table 3.

TABLE 3

TEN-YEAR HISTORY OF THE AIR POLLUTION INDEX (1978-1987)

YEAR	CITY	NUMBER OCCASIONS ≥32	NUMBER OCCASIONS ≥50	MAXIMUM INDEX	DATE OF MAXIMUM
1978	TORONTO	2	0	45	Nov. 5
	HAMILTON	7	0	43	Nov. 4
	SUDBURY	0	0	31	Jan. 22
	WINDSOR (12008)	1	0	33	Apr. 19
	WINDSOR (12016)	0	0	28	Feb. 18
	WELLAND	0	0	24	Mar. 15
	NIAGARA FALLS	0	0	23	Nov. 4, Mar. 11
	CONISTON	3	0	34	Feb. 7
	NEW SUDBURY	1	0	42	Feb. 2
	SARNIA	3	0	41	Jan. 24
1979	TORONTO	2	0	35	Oct. 18
	HAMILTON	23	1	55	Dec. 22
	SUDBURY	0	0	18	July 7
	WINDSOR (12008)	0	0	31	Feb. 20
	WINDSOR (12016)	0	0	27	Feb. 21
	NIAGARA FALLS	0	0	27	Feb. 21
	CONISTON	0	0	31	Feb. 14
	NEW SUDBURY	0	0	28	Feb. 1
	SARNIA	2	0	43	Feb. 2
	ST. CATHARINES	0	0	29	Nov. 6
1980	TORONTO	0	0	31	Dec. 8
	HAMILTON	5	0	40	Oct. 16
	SUDBURY	0	0	23	Oct. 16
	WINDSOR (12008)	0	0	25	Feb. 8, 9
	WINDSOR (12016)	0	0	25	Dec. 29
	NIAGARA FALLS	0	0	18	May 24
	CONISTON	0	0	30	Feb.10, Mar. 9
	NEW SUDBURY	0	0	24	Jul. 3, Oct. 16
	SARNIA	1	0	39	Mar. 20
	ST. CATHARINES	0	0	28	Feb. 20
1981	TORONTO	3	0	43	Nov. 14
	HAMILTON	8	0	38	Nov. 15
	SUDBURY	0	0	21	Jan. 31
	WINDSOR (12008)	1	0	42	Nov. 17
	WINDSOR (12016)	0	0	31	Nov. 17
	NIAGARA FALLS	0	0	25	Jan. 14
	CONISTON	0	0	20	Nov. 25
	NEW SUDBURY	0	0	22	Jan. 28-29
	SARNIA	1	0	34	Feb. 16
	ST. CATHARINES	0	0	27	Jan. 14-15
1982	TORONTO	3	2	54	Oct. 27
	HAMILTON	12	0	39	Dec. 2
	SUDBURY	0	0	15	Feb. 3
	WINDSOR (12008)	0	0	31	Oct. 26-27
	WINDSOR (12016)	1	0	35	Oct. 27
	NIAGARA FALLS	0	0	19	Jan. 19
	CONISTON	1	0	39	Feb. 5
	NEW SUDBURY	0	0	29	Feb. 5
	SARNIA	0	0	27	Mar. 11, Nov. 7-8
	ST. CATHARINES	0	0	31	Nov. 18

TABLE 3 (CONT.)

TEN-YEAR HISTORY OF THE AIR POLLUTION INDEX (1978-1987)

YEAR	CITY	NUMBER OCCASIONS ≥32	NUMBER OCCASIONS ≥50	MAXIMUM INDEX	DATE OF MAXIMUM
1983	TORONTO	3	0	39	Jan. 29
	HAMILTON	1	0	37	Mar. 2
	SUDBURY	1	0	39	Jan. 22
	WINDSOR (12008)	0	0	26	Sep. 27
	WINDSOR (12016)	1	0	33	Mar. 1-2
	NIAGARA FALLS	0	0	17	Jan. 30
	CONISTON	0	0	19	Jan. 15
	NEW SUDBURY	1	1	63	Jan. 22
	SARNIA	0	0	28	Jan. 29
	ST. CATHARINES	0	0	23	Jan. 30
1984	TORONTO	2	1	50	Jan. 16
	HAMILTON	8	0	44	Nov. 27
	SUDBURY	0	0	23	Feb. 1
	WINDSOR (12008)	0	0	31	Oct. 2, Nov. 14
	WINDSOR (12016)	1	0	40	Feb. 15
	NIAGARA FALLS	0	0	20	Dec. 10-11
	CONISTON	0	0	29	Nov. 22
	NEW SUDBURY	0	0	23	Nov. 22
	SARNIA	0	0	27	Jan. 23
	ST. CATHARINES	0	0	24	Feb. 10-11
1985	TORONTO	0	0	25	Apr. 23
	HAMILTON	2	0	36	Apr. 23-24
	SUDBURY	0	0	31	Aug. 4
	WINDSOR (12008)	0	0	25	Dec. 20
	WINDSOR (12016)	0	0	30	Dec. 20
	NIAGARA FALLS	0	0	19	Apr. 24
	CONISTON	0	0	19	Mar. 26
	NEW SUDBURY	0	0	31	Jan. 7
	SARNIA	0	0	20	Mar. 27-28
	ST. CATHARINES	0	0	18	Dec. 6
1986	TORONTO	0	0	22	Jan. 17
	HAMILTON	5	0	37	May 15
	SUDBURY	0	0	23	Oct. 26
	WINDSOR (12008)	0	0	31	Jan. 16, Oct. 22 Dec. 16
	WINDSOR (12016)	0	0	29	Mar. 14
	NIAGARA FALLS	0	0	17	Jan. 17
	CONISTON	0	0	18	Mar. 20-21
	NEW SUDBURY	0	0	20	Apr. 23
	SARNIA	0	0	29	Dec. 17
	ST. CATHARINES	0	0	18	Jan. 17
1987	TORONTO	0	0	31	Oct. 16
	HAMILTON	2	0	38	Oct. 17
	SUDBURY	0	0	26	Mar. 14
	WINDSOR (12008)	0	0	24	Apr. 10
	WINDSOR (12016)	0	0	20	Jun. 25, Oct. 24
	NIAGARA FALLS	0	0	16	Oct. 16-17
	CONISTON	0	0	23	Mar. 9, Mar. 11
	NEW SUDBURY	0	0	22	Mar. 11, Mar. 14, Aug. 27
	SARNIA	0	0	24	Jan. 28
	ST. CATHARINES	0	0	24	Oct. 16-17

SECTION C POLLUTANTS MEASURED BY HIGH VOLUME SAMPLER MONITORING (DAILY DATA)

TSP

TOTAL SUSPENDED PARTICULATE

11.1 Characteristics

Total suspended particulate is a generic term for airborne particles including smoke, fume, dust, fly ash and pollen. Composition varies with place and season but normally includes soil particulates, organic matter, sulphur and nitrogen compounds and metals such as lead. Size range is approximately 0.1 to 100 microns (diameter).

11.2 Effects

The greatest impact on health is from particles less than 10 microns in diameter which can penetrate deep into the lungs and contribute to respiratory disease. More serious health effects may be associated with suspended particulate matter which contains a toxic particulate component or which has absorbed a gaseous pollutant on the surface of the particles. Corrosion, soiling, damage to vegetation and visibility reduction are additional effects.

11.3 Ontario Criteria

120 $\mu g/m^3$ (24 hours)
60 $\mu g/m^3$ (one year – geometric mean)

11.4 Sources

Natural sources include wind-blown soil, forest fires, and plant pollen. Anthropogenic sources include combustion, incineration, construction, mining, metals smelting and processing, grinding processes, agricultural activity and transportation.

11.5 Method of Monitoring

- High Volume Sampler

Air is drawn through a filter at the rate of approximately 1.4 m^3/min. The (daily) mass concentration of total suspended particulate matter is computed from the mass of collected particles and the volume of air sampled.

11.6 Location and Frequency of Monitoring

The monitoring locations and the length of the sampling cycle (in days) for each location are indicated in the Appendix (Table A-3).

TSP was measured at 136 locations in 1987.

11.7 Monitoring Results

The distribution by percentile; the maximum; the arithmetic and geometric means are given in the Appendix (Table A-23). Also given are the number of exceedances of the 24-hour and one-year criteria.

The lowest levels measured in the province were at the Hospital in Blind River where the annual mean was 24 $\mu g/m^3$.

The greatest percentage of exceedances of the 24-hour criterion occurred at Thorold and the highest annual mean was measured there also.

There were a total of 111 stations which exceeded the 24-hour criterion and 34 which exceeded the one-year criterion. (See also Table 4).

11.8 Ten-Year Trend

The trend in mean annual TSP at locations which possess a 10-year record is shown in Table A-24 and is summarized for the province in Table 5. Particulate levels have improved since 1978 by about 15%.

Pb

LEAD IN SUSPENDED PARTICULATE

12.1 Characteristics

- A silver-bluish, white, soft metal
- Molecular weight 207.20

12.2 Effects

Can degrade renal function, impair hemoglobin synthesis, and alter the nervous system.

12.3 Ontario Criteria

5.0 $\mu g/m^3$ (24 hours)
2.0 $\mu g/m^3$ (30 day – geometric mean)

12.4 Sources

- Combustion of gasoline containing lead additives/secondary smelting of lead, battery manufacture, metal fabrication
- Some paint and glass manufacture
- Production of iron, steel, copper and nickel

Lead emissions fell significantly after 1975 with the introduction of lead-free gasoline.

12.5 Method of Monitoring

Lead concentration on high volume filters determined by either X-Ray fluorescence or atomic absorption.

12.6 Location and Frequency of Monitoring

The monitoring locations and the length of the sampling cycle (in days) for each location are indicated in the Appendix (Table A-3).

Lead was measured at 74 locations in 1987.

12.7 Monitoring Results

The distribution by percentile; the maximum; the arithmetic and geometric means are given in the Appendix (Table A-25). Also given are the number of exceedances of the 24-hour criterion.

The greatest percentage of exceedances of the 24-hour criterion occurred at Mississauga (2414 Dixie Road) in the vicinity of a lead processing plant. The highest measured value occurred at Mosley and Leslie Street in Toronto near another secondary lead smelter.

There were a total of four stations (all located near secondary lead smelters) which exceeded the daily criterion at least once. (See also Table 4.)

12.8 Ten-Year Trend

Lead levels in air have improved very significantly over the past 10 years (see Table 5).

The trend at selected Ontario cities is shown in Table A-26; the decline is largely due to the decreased use of leaded gasoline.

TRACE METALS

CADMIUM, COBALT, CHROMIUM, COPPER, IRON, MANGANESE, NICKEL, VANADIUM

13.1 Characteristics

Name	Symbol	Properties	Molecular Weight
Cadmium	Cd	silver white, hexagonal	112.41
Cobalt	Co	silver grey, cubic	58.93
Chromium	Cr	steel grey, cubic	52.00
Copper	Cu	red, cubic	63.55
Iron	Fe	silver, cubic	58.85
Manganese	Mn	grey-pink, cubic	54.94
Nickel	Ni	silver, cubic	58.60
Vanadium	V	light grey, cubic	50.94

13.2 Effects

Depth of penetration into the respiratory system (and consequently risk to health) increase as particle size decreases. Of the heavy metals, cadmium, chromium and vanadium probably pose the greatest risk to human health.

13.3 Ontario Criteria

Cadmium	2 $\mu g/m^3$ (24 hours)
Chromium	1.5 $\mu g/m^3$ (24 hours)
Copper	50 $\mu g/m^3$ (24 hours)
Manganese	10 $\mu g/m^3$ (24 hours)
Nickel	2 $\mu g/m^3$ (24 hours)
Vanadium	2 $\mu g/m^3$ (24 hours)

13.4 Sources

See Section 1.4.

13.5 Method of Monitoring

Collection is by High Volume Sampler (see Section 11.5). Following determination of TSP, a portion is cut from the exposed filter and ashed to destroy carbonaceous matter. The ashed sample is then digested in acid, and analyzed by atomic absorption spectrophotometry. The mass concentration of each metal in ambient air is calculated from the mass of each metal in TSP and the volume of air sampled, and expressed in $\mu g/m^3$.

13.6 Location and Frequency of Sampling

The monitoring locations and the length of the sampling cycle (in days) for each location are indicated in the Appendix (Table A-3).

Refer to Table 4 for the total number of stations at which each element was monitored.

13.7 Monitoring Results

The distribution by percentile of the daily data: the maximum; the arithmetic mean; the geometric mean; and the number of exceedances of the daily criterion are provided in the Appendix for copper, iron, manganese, nickel, chromium, cadmium and vanadium. No table is provided for cobalt where a large percentage of the measurements were below the detection limit. However, the maximum monitored levels for all trace metals are shown in Table A-36.

Table 4 provides the highlights of particulate monitoring for 1987. It shows that no exceedances of the air quality criteria for metals (exclusive of lead) occurred in 1987.

13.8 Ten-Year Trend

The trend in mean annual copper and iron is shown in Tables A-28 and A-30, respectively, and is summarized for Ontario in Table 5. Copper has declined by 30% and iron by 20% over the past 10 years.

NO_3^-

NITRATE

14.1 Characteristics

Nitrogen oxide compounds, formed from atmospheric nitrogen and oxygen through high temperature combustion, photochemical reactions or bacterial action, may react with other compounds in the air to form nitrate (NO_3^-) or nitric acid (HNO_3).

14.2 Effects

Nitrate and nitric acid are involved in corrosion of materials, visibility degradation and acidic precipitation. They may also have an adverse effect on human health.

14.3 Ontario Criteria

None

14.4 Sources

Nitrate is primarily a secondary pollutant. Anthropogenic sources of nitrogen oxides or nitrates include all high temperature combustion processes, transportation, and fertilizer production and usage. Natural sources include lightning, biological decomposition and photochemical reactions.

14.5 Method of Monitoring

Nitrates collected on glass fibre filters by a High Volume Sampler are extracted by digestion in distilled water. This extract is reduced to nitrite followed by colorimetric analysis for determination of the mass concentration of atmospheric nitrate.

14.6 Location and Frequency of Monitoring

The monitoring locations and the length of the sampling cycle (in days) for each location are indicated in the Appendix (Table A-3).

Nitrate monitoring was carried out at 62 locations in 1987.

14.7 Monitoring Results

The distribution by percentile; the maximum; the arithmetic mean; and the geometric mean are given in the Appendix (Table A-37). Highlights of monitoring are summarized in Table 4.

The highest annual mean nitrate concentration occurred at Windsor (University Avenue) while the highest concentration for a single day occurred at the Pickering monitor.

14.8 Ten-Year Trend

The trend in mean annual NO_3^- at locations which possess a 10-year record is shown in Table A-38 and is summarized for the province in Table 5.

Since nitrate is primarily the result of medium and long-range transport of air pollution, its variability is largely related to meteorological variability.

SO_4^{2-} SULPHATE

15.1 Characteristics

Sulphur dioxide is oxidized in the atmosphere to eventually form sulphate compounds. Intermediaries in the oxidation process such as HSO_3 and SO_3 rapidly combine with water vapour to form sulfuric acid aerosol. This type of process is dependent on atmospheric conditions.

15.2 Effects

Sulphate compounds have been linked to respiratory irritation and disease, corrosion of materials, reduction of visibility and the formation of acidic precipitation.

15.3 Ontario Criteria

None

15.4 Sources

Sulphate is primarily a secondary pollutant. Anthropogenic sources of sulphur oxides include the burning of fuels containing sulphur (such as coal and oil), the smelting of sulphur-containing ores and the refining of petroleum. Natural sources include bacterial decomposition, volcanoes and forest fires.

15.5 Method of Monitoring

Sulphate collected on glass fibre filters by a High Volume Sampler is extracted by digestion in distilled water. This extract is analyzed colorimetrically and the mass concentration of sulphate is calculated.

15.6 Location and Frequency of Monitoring

The monitoring locations and the length of the sampling cycle (in days) for each location are indicated in the Appendix (Table A-3).

Sulphate monitoring was carried out at 62 locations in 1987.

15.7 Monitoring Results

The distribution by percentile; the maximum; the arithmetic mean; and the geometric mean are given in the Appendix (Table A-39). Highlights of monitoring are summarized in Table 4.

The highest annual mean sulphate concentration was measured at Hamilton (Barton/Wentworth), and the highest concentration for a single day occurred at Windsor (University Avenue).

15.8 Ten-Year Trend

The variability of the annual means for sulphate (see Tables 5 and A-40) may be explained by meteorological variability as in the case of nitrate (Section 14.8).

TABLE 4 – HIGHLIGHTS OF PARTICULATE MONITORING 1987

	TSP	Pb	Cu	Fe	Mn	Ni	NO_3	SO_4
LOWEST GEOM MEAN								
Location	Blind River (71065)	Several	London (15015) S.S. Marie (71042)	Several	Mooretown (14031)	Kitchener (26029) North Bay (75010)	Timmins (72077)	Thunder Bay (63022)
Concentration	24 $\mu g/m^3$	0.1 $\mu g/m^3$	0.1 $\mu g/m^3$	0.1 $\mu g/m^3$	.009 $\mu g/m^3$	.003 $\mu g/m^3$	0.5 $\mu g/m^3$	2.7 $\mu g/m^3$
HIGHEST GEOM MEAN								
Location	Thorold (27052)	Mississauga (46041)	Nanticoke (22907)	Hamilton (29011)	Hamilton (29011)	Copper Cliff (77070)	Windsor (12008)	Hamilton (29025)
Concentration	167 $\mu g/m^3$	2.1 $\mu g/m^3$	0.80 $\mu g/m^3$	5.0 $\mu g/m^3$	.318 $\mu g/m^3$	.156 $\mu g/m^3$	5.2 $\mu g/m^3$	13.0 $\mu g/m^3$
PERCENTAGE OF SAMPLES ABOVE 24 HRS AQC								
Location	Thorold (27052)	Mississauga (46041)						
Number	71	27	0	N/A	0	0	N/A	N/A
NUMBER OF STATIONS EXCEEDING 24 HR AQC								
Number	111	4	0	N/A	0	0	N/A	N/A
NUMBER OF STATIONS EXCEEDING 1 YR AQC								
Number	34	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HIGHEST MEASURED VALUE – 24 HRS								
Location	Hamilton (29119)	Toronto (31058)	Copper Cliff (77070)	Copper Cliff (77070)	Hamilton (29025)	Port Colborne (27047)	Pickering (45001)	Windsor (12008)
Concentration	489 $\mu g/m^3$	38.7 $\mu g/m^3$	7.58 $\mu g/m^3$	53.5 $\mu g/m^3$	5.29 $\mu g/m^3$	1.64 $\mu g/m^3$	33.8 $\mu g/m^3$	91.9 $\mu g/m^3$
TOTAL NUMBER OF STATIONS								
Number	136	74	58	64	62	60	62	62

TABLE 5 – TEN-YEAR TREND FOR PARTICULATE POLLUTANTS

POLLUTANT (UNITS)	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	TOTAL NUMBER OF STATIONS
TSP ($\mu g/m^3$)	56	62	61	53	49	47	48	43	46	47	26
Pb (.1 $\mu g/m^3$)	4	3	3	3	2	2	2	2	2	1	14
Cu (.01 $\mu g/m^3$)	24	23	25	19	17	21	18	17	15	17	18
Fe (.1 $\mu g/m^3$)	13	11	12	8	7	7	7	8	7	10	18
NO_3^- (.1 $\mu g/m^3$)	32	35	32	31	31	29	29	28	27	27	16
SO_4^{2-} (.1 $\mu g/m^3$)	81	104	105	91	83	81	82	68	74	85	16